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ABSTRACT

Reported is a study designed (1) to investigate the relationship between teacher-assigned chemistry grades and the scores obtained on a multiple-choice chemistry test built on taxonomic principles, and (2) to compare the contributions of various predictor variables to the explainable variance of the grades and the total test scores. The sample consisted of 2339 grade twelve chemistry students enrolled in the General Course in Ontario High Schools. Part one of the study was accomplished by computing Pearson product-moment correlation coefficients between subject scores on the Ontario Test of Achievement in Chemistry (OTAC), an investigation constructed test, and teacher-assigned grades as well as students' scores on the Scholastic Aptitude Test, Ontario edition (SATO) 1963-64. The results indicate that teacher-assigned grades are not highly related to the OTAC score. To carry out part two of the study, the University of Michigan Automatic Interaction Detector computer program was used to identify variables contributing to the explainable variance of the two sets of achievement scores. This program also isolated groups of students in which different combinations of the predictor variables functioned most effectively. (LC)

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RELATIONSHIPS OF TEACHER-ASSIGNED GRADES IN HIGH SCHOOL CHEMISTRY TO TAXONOMY-TYPE OBJECTIVE TEST SCORES

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This present study was designed (a) to investigate the relationship between teacher-assigned chemistry grades and the scores obtained on a multiple-choice chemistry test built on taxonomic principles, and (b) to compare the contributions of various predictor variables to the explainable variance of the grades and the total test scores.

The cognitive objectives studied were restricted to *Knowledge*, *Comprehension*, *Application*, and *Analysis* as defined by the Taxonomy of Educational Objectives: Cognitive Domain.[1] The Ontario Test of Achievement in Chemistry (OTAC), a 60-item end-of-course test designed to measure these cognitive objectives, was constructed and developed over a three-year period. Each cognitive objective was represented by a subtest; approximately 40% of the items were devoted to testing Category 1.00 *(Knowledge)*, with the remaining items split almost equally among Categories 2.00, 3.00 and 4.00 of the Taxonomy. The test was administered in mid-May of 1964..

The sample consisted of 2339 Grade 12 Chemistry students enrolled in the General Course (a college-preparatory course) in Ontario high schools. Of 50 schools selected at random, 30 schools agreed to participate in the study, thus making available 48 teachers and 80 classes of chemistry students.

Students' scores on the Scholastic Aptitude Test, Ontario

edition (SATO) 1963-64 were retrieved from existing files. Students responded to the Inventory of Choices, a measure of attitudinal orientation devised by Edwards and Wilson.[2,3] Other information collected included final grades (marks) in chemistry, sex of student, immediate and future educational plans, occupational aspiration of the student, occupation of father and mother, language spoken in the home, type of school, and some characteristics of the home environment, the school environment, and the teacher.

Pearson product-moment correlation coefficients were computed to carry out part (a) of the study. To carry out part (b) of the study, the University of Michigan Automatic Interaction Detector (AID) computer program[4] was used to identify variables contributing to the explainable variance of the two sets of achievement scores. This program also isolated groups of students in which different combinations of these predictors functioned most effectively.

The results of part (a) of the study are presented in Table 1.

TABLE 1

CORRELATIONS BETWEEN FINAL CHEMISTRY MARK AND OTAC SCORES

Score or Grade	No. of Items	Final Chemistry Grade	SATO Total Verbal	SATO Mathematics
Category 1.00, *Knowledge*	23	.48	.44	.43
Category 2.00, *Comprehension*	11	.44	.43	.53
Category 3.00, *Application*	14	.49	.45	.56
Category 4.00, *Analysis*	12	.32	.32	.29
OTAC Total	60	.56	.53	.58
Final Chemistry Grade	-	-	.32	.37

Examination of Table 1 shows that teacher-assigned grades are not highly related to either the total OTAC score or the Taxonomy subtests. It appears that OTAC and teachers of chemistry are to a large extent not measuring the same accomplishments. The correlation of Category 4.00 to Final Chemistry Grade is considerably lower than the corresponding correlation of other Taxonomy subtest scores.

Inspection of Table 1 also shows that teacher-assigned grades are not as highly related to scholastic aptitude as are most OTAC scores, with the exception of Category 4.00 scores. The correlation of final chemistry grades to *SATO Mathematics* is higher

than the correlation to *SATO Total Verbal*; a similar relationship is observed for OTAC Total scores, Category 2.00 scores and Category 3.00 scores. The reverse relationship is observed with Category 4.00 scores and SATO scores.

For the Taxonomy subtests the correlations with final chemistry grades are approximately the same as with *SATO Total Verbal* scores, with slightly less agreement being observed for the correlations between Taxonomy subtests and *SATO Mathematics* scores.

Tables 2 to 6 and Figures 1 and 2 present the results of part (b) of the study.

TABLE 2

ABBREVIATIONS FOR INDEPENDENT VARIABLES
USED IN AID ANALYSIS

Abbreviation	Variable
SATO TV	Scholastic Aptitude Test (Ontario)—Total Verbal Score
SATO MATH	Scholastic Aptitude Test (Ontario)—Mathematics Score
P-T 4	Inventory of Choices, Prudent-Theoretic 4-point scale
P-I 4	Inventory of Choices, Prudent-Immediate 4-point scale
P-A 4	Inventory of Choices, Prudent-Aesthetic 4-point scale
T-I 4	Inventory of Choices, Theoretic-Immediate 4-point scale
T-A 4	Inventory of Choices, Theoretic-Aesthetic 4-point scale
A-I 4	Inventory of Choices, Aesthetic-Immediate 4-point scale
SEX	Sex of student
OCCF	Occupation of father
OCCM	Occupation of mother
OCCS	Occupational aspiration of student
REPEATING	Repeating Grade 12 Chemistry
ATTITUDE	Attitude toward school 6-point scale
LANGUAGE	Language spoken in the home
ED PLANS 1	Immediate educational plans
ED PLANS 2	Future educational plans
SCHOOL TYPE	Publicly supported, Roman Catholic, Independent private
TEXT	Textbook used in chemistry class

TABLE 3

INTERPRETATION OF CATEGORICAL VARIABLES
APPEARING IN AID TREES

Variable	Code	Interpretation
ED PLANS 1	0	not indicated
	1	complete Grade 12 only
	2	complete Grade 13
	3	leave before completing Grade 12
	4	undecided
P-T 4	0	highly theoretic orientation
	1	moderately theoretic orientation
	2	moderately prudent orientation
	3	highly prudent orientation
T-I 4	0	highly immediate orientation
	1	moderately immediate orientation
	2	moderately theoretic orientation
	3	highly theoretic orientation
REPEATING	0	not indicated
	1	not repeating Grade 12 Chemistry
	2	repeating Grade 12 Chemistry

KEY:

Percentage in Group - 40%
Group No. - 4

SATO MATH
0-24
20.7

- Variable causing split
- Range of splitting variable contained in group
- Mean of group

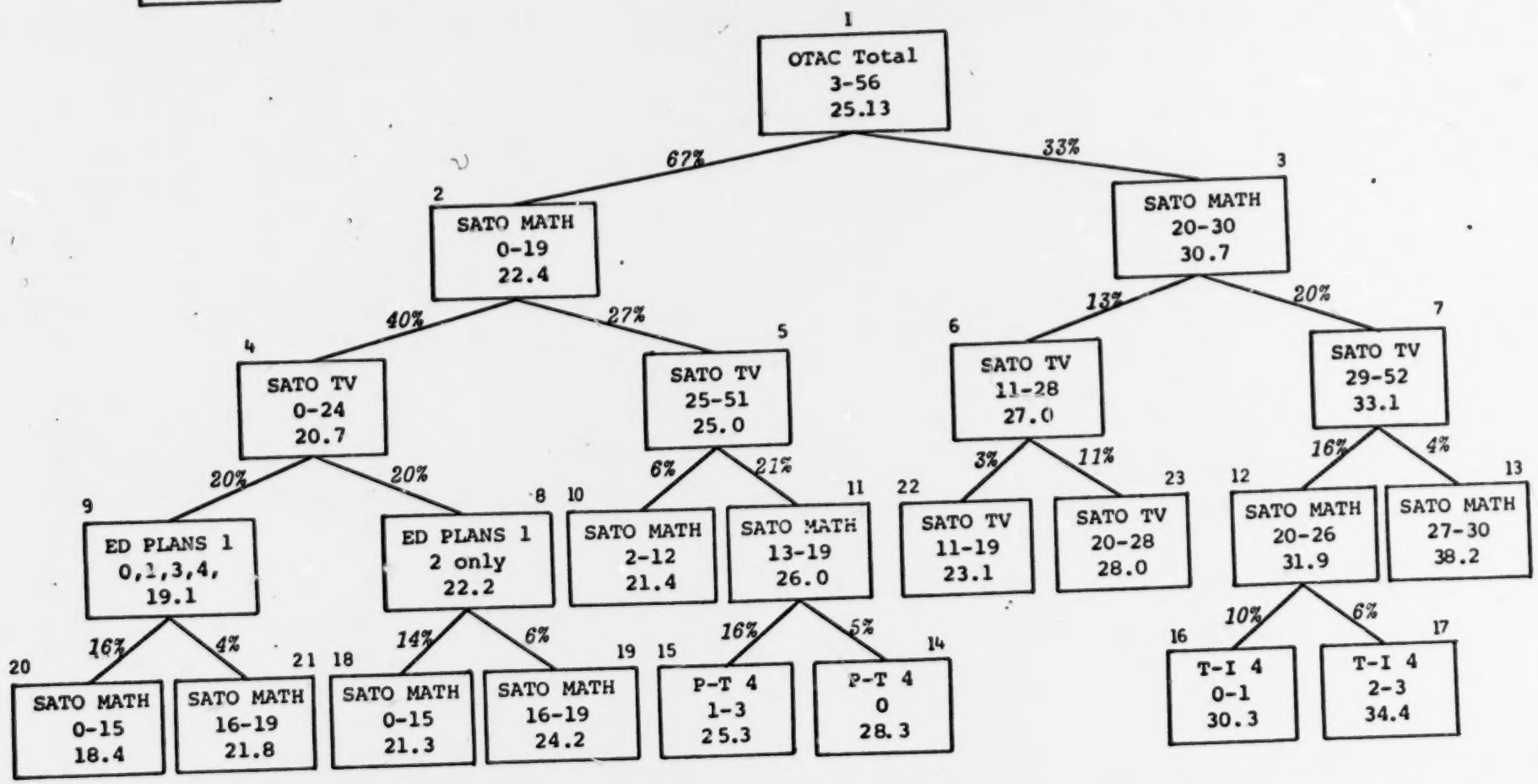

FIG. 1 - AID Tree for OTAC Total Scores

TABLE 4

AID ANALYSIS FOR RUN NO. 1 -
OTAC TOTAL SCORE
(Between-Group Sum of Squares for Each Predictor at Each Stage) × 10^2

Variable	Group Number																							
	1	2	3	4	5	7	11	12	8	9	15*	6	22†	18*	20*	16*	23*	17*	14*	19*	10*	21*	13*
2 SATO TV	291	(72)	(68)	9	11	12	7	2	3	2	5	(12)	4	3		2	2	1	10	4	5	2	7
3 SATO MATH	(354)	72	50	22	(21)	(28)	6	7	(8)	(9)	5	5	4	3		3	5	3	1	0	2	0	2
4 P-T 4	31	8	12	3	10	17	(8)	1	1	3	0	4	2	3		3	3	3	1	0	1	2	3
5 P-I 4	114	2	7	0	0	0	0	1	0	1	0	2	1	0		1	2	2	0	1	0	1	0
6 P-A 4	11	4	2	3	1	3	1	4	1	1	0	1	0	1		2	1	0	2	0	0	0	0
7 T-I 4	42	6	21	5	2	21	2	(16)	2	4	3	4	2	3		2	3	1	1	1	0	1	3
8 T-A 4	36	4	15	2	1	13	0	10	1	1	1	2	2	1		5	1	1	0	0	2	0	1
9 A-I 4	11	2	6	0	0	3	0	2	0	0	1	0	1	0		0	0	2	1	1	1	1	1
10 SEX	68	8	6	9	5	6	0	5	5	5	1	4	3	3		1	3	3	0	0	3	0	0
11 OCCF	5	-	1	0	1	0	0	1	2	2	0	1	1	1		1	1	1	1	1	2	1	1
12 OCCM	6	5	1	1	1	0	2	1	0	2	1	1	2	2		1	2	1	0	1	2	0	1
13 OCCS	55	6	12	4	5	9	5	8	2	3	3	3	2	2		5	2	3	3	0	1	1	1
14 REPEATING	1	2	5	5	1	2	0	2	3	7 ◄	1	1	2	2		1	1	2	1	1	0	5	0
15 ATTITUDE	7	4	4	0	4	3	4	2	0	1	4	1	0	1		1	0	2	0	1	0	1	2
16 LANGUAGE	0	1	2	2	0	2	0	3	2	2	0	1	2	1		1	0	1	0	0	0	1	2
17 ED PLANS 1	147	47	27	(23)	6	8	4	9	-	1	3	8	-	1		6	3	3	1	-	1	1	0
18 SCHOOL TYPE	4	0	7	1	0	7	0	8	1	1	1	2	1	1		5	1	2	2	0	1	0	2
19 TEXT	0	1	0	0	0	0	1	1	0	0	0	0	0	1		1	0	0	1	0	0	0	0

* Unexplained Final Group
† Explained Final Group

(○) Split made on this variable
◄ Points to next best splitting variable

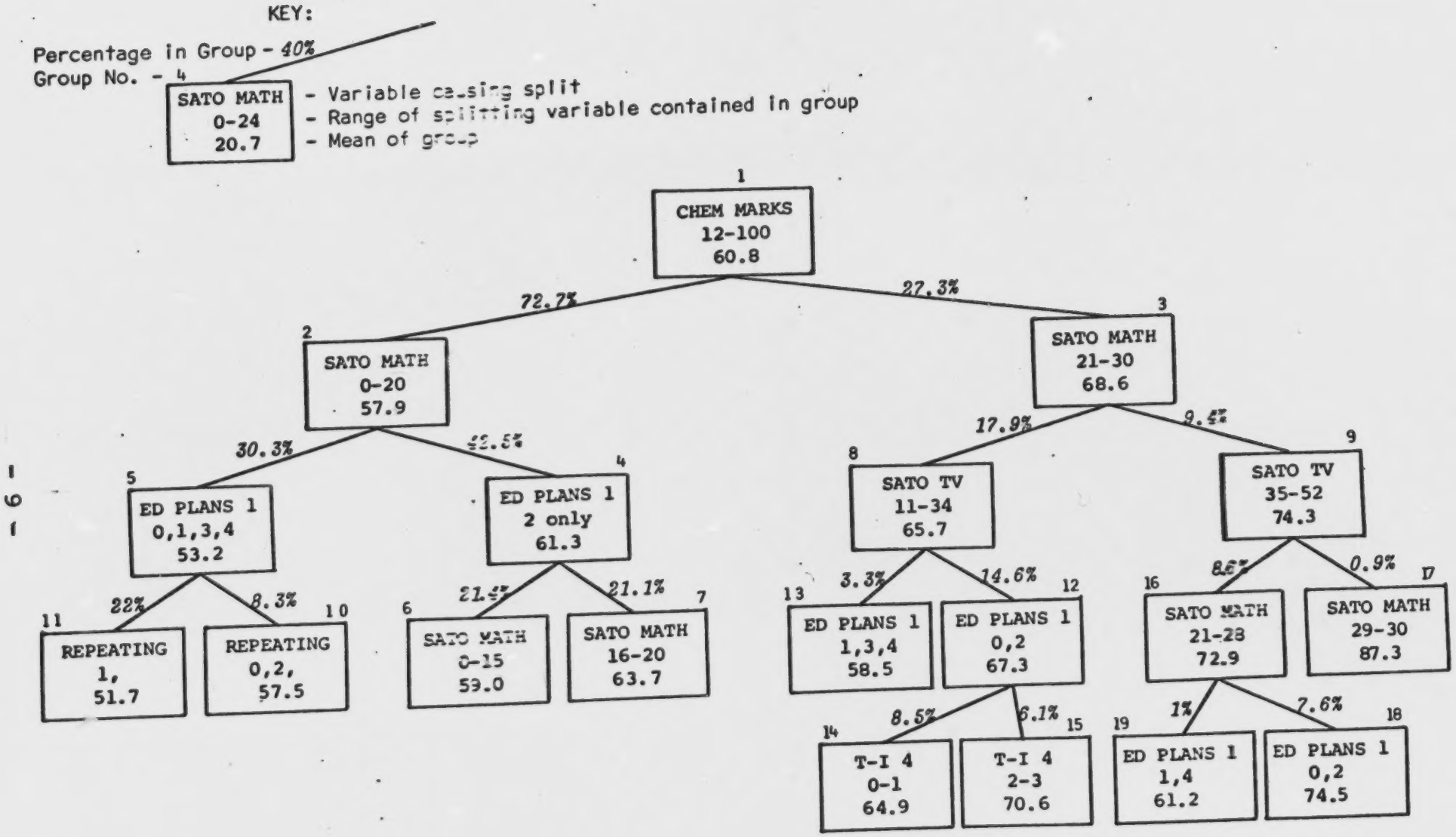

FIG. 2 - AID Tree for Chemistry Marks

TABLE 5

AID ANALYSIS FOR RUN NO. 5 -
CHEMISTRY MARKS
(Between-Group Sum of Squares for Each Predictor at Each Stage) × 10^2

Variable		Group Number																		
		1	2	4	3	5	11*	8	7*	6*	12	9	16	17¶	14*	10*	15*	18*	19¶	13*
2	SATO VERB	97	28	7	(26)	5	5	7	4	4	5	2	1		4	5	3	1		3
3	SATO MATH	(131)	33	(14)	13	8	5	7	1	3	6	(9)	2		4	1	1	1		1
4	P-T 4	24	9	11◄	8	2	2	8	4	5	4	3	1		3	1	0	1		5
5	P-I 4	7	3	0	3	1	2	3	1	4	1	1	1		1	1	1	1		3
6	P-A 4	12	10	2	3	2	4	1	1	1	1	1	1		2	0	1	1		0
7	T-I 4	43	16	9	17	4	5	8	3	5	(7)	7	5		1	4	0	3		1
8	T-A 4	27	12	5	4	5	5	3	3	2	3	0	0		1	1	1	1		1
9	A-I 4	5	1	1	3	1	1	0	1	0	0	2	1		1	0	1	1		1
10	SEX	4	2	0	2	1	1	0	1	0	0	1	2		0	2	0	1		0
11	OCCF	6	4	2	2	3	5	1	3	0	1	2	2		2	2	2	1		1
12	OCCM	2	3	0	3	4	3	1	0	0	0	3	4		1	2	2	1		1
13	OCCS	28	14	2	4	2	1	3	1	2	2	2	2		2	2	0	1		0
14	REPEATING	4	2	2	3	(12)	1	0	0	1	0	2	2		0	2	1	3		2
15	ATTITUDE	21	15	4	12	6	6	5	6	1	4	4	4		3	2	1	2		1
16	LANGUAGE	3	3	2	1	9	0	0	2	0	0	0	1		1	2	1	0		2
17	ED PLANS 1	130	(66)	-	24	3	2	(12)	-	-	0	8	(9)		0	2	0	0		1
18	SCHOOL TYPE	9	3	1	12	2	1	6	0	2	4	3	3		5	1	0	1		0
19	TEXT	15	9	6	3	5	3	3	4	1	3	1	1		5	1	0	0		0

* Unexplained Final Group
¶ Small Final Group

◯ Split made on this variable
◄ Points to next best splitting variable

TABLE 6

CONTRIBUTION OF IMPORTANT VARIABLES TO OTAC TOTAL SCORE VARIANCE AND FINAL CHEMISTRY MARK VARIANCE

Variable	Percent of Variance Explained	
	for OTAC Total Score	for Final Chemistry Mark
SATO Math	27.55	11.62
SATO TV	10.66	1.97
Ed Plans 1	1.50	6.52
T-I 4	1.02	0.50
P-T 4	0.54	-
Repeating	-	0.90
Total	41.27	21.51

The Automatic Interaction Detector program permits comparisons of the components of variance of OTAC scores and final chemistry grades that are not evident in correlation studies. Both AID runs used the same set of explanatory variables. Comparison of the two "AID trees" (Figures 1 and 2, Tables 3, 4, 5, and 6) yields the following observations:

SATO Mathematics is the best splitting variable for both OTAC scores and final chemistry marks; both splits are very much alike.

SATO Total Verbal is the next best splitter, for both OTAC scores and final chemistry marks, for those students obtaining an above-average score in *SATO Mathematics*.

For students who do not obtain an above-average score in *SATO Mathematics*, *SATO Total Verbal*, the next best splitter for OTAC scores, is not as effective as *immediate educational plans* in splitting groups when final chemistry marks is the dependent variable. In other branches and twigs of the final chemistry mark AID tree, *immediate educational plans* supplants *SATO Total Verbal* as a predictor.

The *Theoretic-Immediate* variable operates more effectively in a different verbal aptitude range in explaining final chemistry marks than it does in explaining OTAC scores.

The *Prudent-Theoretic* variable does not effectively split

any final chemistry marks group, although the variable is useful in explaining the variance of OTAC scores.

The variable *Repeating*, which did not function effectively in explaining OTAC Total scores, is a good predictor of final chemistry marks for students of moderate to low mathematical ability who do not plan to enter university.

The percentages of variance explained by the effective splitters for the two dependent variables are compared in Table 6.

It is seen that those independent variables that are useful as predictors for both dependent variables operate to explain the variance of the dependent variables in quite different ways. The ratio of *SATO Mathematics* to *SATO Total Verbal* in terms of variance explained is especially striking. Also of note is the effectiveness of *immediate educational plans* compared to *SATO Total Verbal* as a predictor of final chemistry marks.

The findings also suggest that the same accomplishments are not being measured by grades and OTAC scores, and that comparatively little emphasis has been placed, either in teaching or examining, on the achievement of abilities that are subsumed under the cognitive objective *Analysis*.

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